An Enhanced Global Precipitation Measurement (GPM) Validation Network Prototype

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A Validation Network (VN) prototype is currently underway that compares data from the Precipitation Radar (PR) instrument on NASA's Tropical Rainfall Measuring Mission (TRMM) satellite to similar measurements from the U.S. national network of operational weather radars. This prototype is being conducted as part of the ground validation activities of NASA's Global Precipitation Measurement (GPM) mission. GPM will carry a Dual-frequency Precipitation Radar instrument (DPR) with similar characteristics to the TRMM PR. The purpose of the VN is to identify and resolve significant discrepancies between the U.S. national network of ground radar (GR) observations and satellite observations. The ultimate goal of such comparisons is to understand and resolve the first order variability and bias of precipitation retrievals in different meteorological/hydrological regimes at large scales. This paper presents a description of, and results from, an improved algorithm for volume matching and comparison of PR and ground radar observations.

The core VN data consist of matched sets of TRMM PR reflectivity and quality-controlled, ground-based WSR-88D (Weather Surveillance Radar – 1988 Doppler) radar reflectivity for 21 sites in the southeastern United States. A new overpass event is added to the VN data set each time the TRMM PR ground track passes within 250 km of one of the VN ground radars. For each event, a WSR-88D volume scan (Level II archive product) for the closest volume scan beginning at or prior to the satellite overpass is acquired and subjected to automated and manual quality control. On average, about 48 coincident overpass events occur per site, per month.

Coincident PR data consist of spatial subsets of the standard TRMM 1C-21, 2A-23, 2A-25, and 2B-31 products, which include radar reflectivity (both raw and attenuation corrected), derived rain rate, and other parameters. The PR spatial domain for the core VN region is a latitude/longitude bounding rectangle extending from 24° to 35° N and 80° to 98° W. Both the original Level II and final quality-controlled WSR-88D products and the original PR products are retained in the VN data archive. The current period of record for the core VN data starts on August 8, 2006 and runs to the present.

PR-to-GR match-up products are generated from the VN data set for "significant precipitation cases." Such cases occur when at least 100 4-km grid points within 100 km of the GR indicate "rain certain" as defined by the PR 2A-25 Rain Flag. Of all coincident overpass events having matched PR and GR products, about 3.5 per month meet the 100-in-100 criterion.

A VN "geometry matching" algorithm is now in operation that matches PR and GR data based on calculating average radar reflectivity at the geometric intersection of the PR rays and the GR elevation sweeps. To mitigate beam filling and bright band contamination effects in the GR data, the intersection points processed in the match-up

are restricted to those within 100 km of the ground radar site. The along-ray PR data are averaged only in the vertical, between the top and bottom height of each GR elevation sweep intersected in the GR volume scan. The GR data are distance weighted and averaged only in the horizontal on the individual PPI surfaces, for each intersecting PR ray, over an area centered on the PR ray's parallax-adjusted footprint. No interpolation or smoothing is performed. Case by case, the resulting match-up points are at variable locations in the horizontal and vertical, as defined by the location of the PR rays and the intersection of the PR ray with each of the GR sweeps.

Each match-up data set contains coincident TRMM PR data and WSR-88D data for a significant precipitation event at a specific GR site. Data for events that meet these criteria are stored in netCDF files, one file per event. Reflectivity comparison statistics are routinely generated from the match-up data on a site-by-site basis. Tables of mean error, standard deviation, and bias are computed for each event for a selected vertical level. Event-specific products such as probability density function and vertical reflectivity profiles are also produced. Information contained in the data set allows the input data to be restricted to match-up points where reflectivities for all PR and GR bins contributing to the averages for the matching volume are above selected thresholds, such that beam-filling effects are minimized.

Graphics summarizing pooled data over a specific time period are also generated, including histograms and scatter plots of reflectivity, and time series of reflectivity and rain rate bias. Results may be stratified between convective and stratiform rain, whether the data lie over land, coast or ocean, vertical proximity to the bright band (above, within, below), and distance from the ground radar.

As the number of coincident precipitation events has grown, the statistical products have begun to provide statistically significant information on the reflectivity calibration accuracy and stability of the WSR-88D radars relative to the well-calibrated TRMM PR. Sample results for GR sites with small and large differences relative to the PR will be shown.

The VN is being used as a tool for evaluating the current TRMM PR attenuation correction algorithm. It is expected that these investigations will be used as a prototype for validating the attenuation correction and precipitation retrieval algorithms of the Dual-frequency Precipitation Radar (DPR) in the GPM era. Additional TRMM and ancillary data products are under consideration for inclusion within the VN data acquisition and processing framework in support of TRMM and GPM algorithm development and evaluation, such as TRMM Microwave Imager (TMI) products and atmospheric forecast model fields.

Although the VN currently supports 21 match-up sites operationally, the network was designed to be scalable. Several additional sites have already been added, including the Kwajalein S-POL radar; the Darwin, Australia C-POL radar; the ARMOR C-POL radar in Huntsville Alabama; and the Gosan, Korea S-band radar. Plans are underway to add more U.S. domestic and international validation sites, and additional participants are welcome to join the network.